REPORT OF THE

Tropical Products Institute

1959

Department of
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Research

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Cover photograph: Nigerian carrying palm oil fruit

DEPARTMENT OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE TROPICAL PRODUCTS INSTITUTE 1959

The Report of the
Tropical Products Institute Committee
with the Report of the
Director of the Tropical Products Institute

LONDON
HER MAJESTY'S STATIONERY OFFICE
1960

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* Mr. Trafford Smith took Mr. W. B. L. Monson's place on the Committee during the year.

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REPORT OF THE TROPICAL PRODUCTS INSTITUTE COMMITTEE FOR 1959

To the Council for Scientific and Industrial Research

WE, the Tropical Products Institute Committee, beg leave to present a report of our proceedings for the period 1st April, 1959, to 31st December, 1959.

On the 1st April, 1959, the Tropical Products Institute became one of the research stations of the Department of Scientific and Industrial Research. The basic reason for this development was to be found in the changing shape and nature of the Commonwealth. Countries which had recently achieved independence, and thus no longer came within the scope of the Colonial Office, might still wish to avail themselves of the services of the Institute. In these circumstances it was more appropriate that the Institute should be placed under the control of the Department, whose Minister (the Minister for Science) has wider responsibilities for research in the civilian field.

We were set up on the 1st April, 1959, as a Committee of the Research Council, with the following terms of reference:

(1) To be responsible to the Research Council for the selection of projects and for the allocation of effort to them, within the financial resources allocated to the Station or other limits imposed by Council.

(2) To report annually to the Research Council, submitting a research programme for the following year.

We were also empowered to appoint sub-committees to advise us on special fields of research being undertaken by the Institute.

The main objective of the Institute is to improve the economic viability of the under-developed territories of the tropics, primarily those that form part of the Commonwealth. To this end, the Institute has as its aim the improvement of the technology of industries that already exist and the introduction of new industries as a result of research into new uses for tropical plant and animal products (including waste products of existing industries). Prior to the date that the Institute became a part of the Department of Scientific and Industrial Research, the Secretary of State for the Colonies had approved an expansion of its staff, following its move to new premises in Gray's Inn Road. This expansion was endorsed by the Council for Scientific and Industrial Research to proceed to completion in 1959/60. It was linked with a proposed re-organisation of the Institute into four divisions: the Advisory Division, the largest in the Institute in terms of Scientific and Experimental staff, which was to continue to deal with the wide variety of enquiries and problems on tropical products submitted to the Institute by Government departments, industrial concerns, merchants, etc., at home and overseas; the Research Division, which was in the process of being formed to study selected projects of a long-term nature likely to have importance for those tropical countries most needing assistance; an Economics Division, to carry out market research and economic surveys of value to tropical countries and to assist in the selection of suitable projects for research and development

and in the advisory work of the Institute; and an Administrative and Development Division in which the Development Section would select and examine promising projects for development, with a view to providing new industries and improving existing ones.

We have, at the request of the Council for Scientific and Industrial Research, examined the 5-year plan programme for 1959/64, drawn up by the Director of the Institute. We have agreed this programme, which will involve a further small expansion, mainly in laboratory assistant staff. In determining the programme of work of the Institute we have been guided largely by three main considerations. We are anxious that the effort available should not be diffused over too many projects, and in this connection have welcomed the role of the Economics Division in assisting in the selection of suitable projects for research. We have decided, for example, that work on bacterial cellulose for viscose production should be stopped. Secondly, we wish to give priority to those projects which are directed towards immediate industrial problems or which promise application within a relatively short period. With this object in mind, we have specifically advised on the programme of the Research Division and have emphasised that more effort should be spent on the determination of the composition of natural oils than on castor meal and that greater attention should be paid to those plants containing active principles affecting the mind and blood pressure than on those having an analegesic effect or those affecting blood sugar levels where synthetic drugs exist to achieve the required effects. Thirdly, we are anxious that the Institute should look to the future development of industries in tropical countries, and we believe that a proportion of its time should be spent on research of a longer-term nature, always, of course, with practical objectives in view.

In order that the Institute should strengthen its contacts with overseas territories, we feel it is necessary for members of the staff to visit tropical, particularly Commonwealth, territories regularly. We have therefore agreed that each of the five major regions containing dependent and newly-independent Commonwealth countries (East Africa, West Africa, Central Africa, the Caribbean, South-east Asia and Pacific) should receive visits not less frequently than once a year and that smaller, less accessible, territories should have two visits in every five years.

We consider, furthermore, that the extra-departmental contracts placed on behalf of the Institute with University Departments overseas, are also of value in stimulating closer contacts with overseas territories as well as in the prosecution of fundamental research.

Finally, it is our view that the Institute should, in general, continue to act as the central laboratory for advisory, research and development work of interest to Commonwealth and Colonial areas.

CHARLES DODDS,
Chairman

March, 1960

REPORT OF THE DIRECTOR OF THE TROPICAL PRODUCTS INSTITUTE FOR 1959 (1st APRIL - 31st DECEMBER)

INTRODUCTION

DESPITE the establishment of new Research and Development Divisions, the Tropical Products Institute remains primarily an advisory body, its effort being largely devoted to the numerous and varied requests received from all over the world for technical assistance concerning tropical plant and animal products.

During the nine month period under review, 713 enquiries were answered, of which 101 required laboratory investigation. Enquiries were received from the 81 different countries listed in Appendix II, from which it is clear that most assistance is at present being given to Colonial territories in East and West Africa, and the West Indies. Comparatively few requests were received from British territories in the Far East and the Pacific.

SENIOR STAFF CHANGES

In July, Mr. H. T. Islip retired from the post of Assistant Director, Advisory Division, after 40 years' service in the Institute and its parent body, the Plant and Animal Products Department of the Imperial Institute. His successor is Mr. T. A. Oxley, formerly of the Pest Infestation Laboratory.

Dr. L. Horton was appointed in September to the post of Assistant Director in charge of the new Research Division.

The Institute is divided into four divisions—Advisory, Economics, Research, and Administration and Development.

ADVISORY DIVISION

This Division deals with the wide variety of enquiries concerning the renewable resources of the tropics, submitted to the Institute by Government Departments, commercial concerns, merchants and individuals, both at home and overseas. 646 enquiries, of which 101 required laboratory investigation, were dealt with in the period under review by the specialised sections of this Division. Examples of some of the more interesting problems are given below.

ESSENTIAL OILS, SPICES, GUMS AND RESINS

Pine oleo-resin from British Honduras

Because of difficulties in the supply of rosin, some of the large American firms producing naval stores (turpentine and rosin) have been looking for new sources of supply and there has been renewed interest in the forests of *Pinus caribaea* in British Honduras. For this reason, a recent examination of these products obtained from British Honduras pine is of particular interest.

A sample of oleo-resin was specially collected using glass collecting cups on the trees and palm leaves as gutters in order to avoid contamination with iron

salts and rust. This had spoiled earlier samples, causing the rosin to be very dark in colour. The oleo-resin was distilled at the Institute to obtain the turpentine and rosin.

A detailed analysis of the turpentine was undertaken, using gas chromatography, to determine the major constituents present and their approximate proportions. This revealed that the oil contained over 70 per cent of α-pinene, a much higher proportion than the usual 64 per cent in American turpentine which comes from the closely related species *Pinus elliottii*. In view of the increasing tendency to isolate α-pinene for use as a starting material for organic syntheses in the chemical industry, this could be a favourable feature. The examination also showed a lower proportion of β-pinene (about 5 per cent) and quantities of myrcene and β-phellandrene. These last two compounds, which polymerize easily, may have been responsible for the rather high percentage of residue which remained when the turpentine was distilled. Apart from the fact that the percentage distilling below 170°C was just less than the minimum requirement, the turpentine satisfied both the British Standard Specification for turpentine (Type 1) and the A.S.T.M. Specification (D13-51) for Spirits of Turpentine.

The rosin obtained from this sample of oleo-resin was very clear and pale (paler than X on the U.S. Department of Agriculture Standard Scale) showing that oleo-resin from British Honduras can yield a rosin with the best colour quality provided sufficient care is taken in collection and distillation. The rosin had rather a low melting point, but in all other respects the analytical constants were within the ranges for rosin from the United States.

Nutmeg leaves from Grenada

At the request of the Grenada Nutmeg Association, which had received an order for nutmeg leaves for distillation, the Institute examined samples of the leaves to see if they might have any value in the trade as a source of a kind of nutmeg oil. The leaves were of two kinds: brown dried leaves and green leaves, the former giving a rather higher yield of oil. Except for small differences in optical rotation and alcohol solubility, the analytical constants of the leaf oils were within the ranges given in the literature for genuine West Indian nutmeg oils, and examination by gas chromatography confirmed that the two types of oil were of similar composition with only small differences in the proportions of the constituents. The odour of the oils on paper was at first unpleasant and quite unlike nutmeg oil, but on airing it became rather like that of a mixture of nutmeg and sage oils. The trade reported the flavour of the oils to be poor and generally deprecated their production.

It was recommended to Grenada that any possible trade in nutmeg leaves should be undertaken only after very careful consideration, since the oil would probably be used as an adulterant or substitute for genuine nutmeg oil and the final result might be harmful to the producers.

"*Fevergrass*" *oil from Antigua*

The Department of Agriculture, Antigua, submitted a sample of oil distilled from the local "fevergrass" which grows wild in one part of the island. The botanical name of the grass was not known. The oil was found, both from its analytical constants and by gas chromatography to resemble closely the East Indian type of lemongrass oil, but it was superior to this oil in having a higher

citral content. Firms in the trade were favourably impressed with "fevergrass" oil which they would prefer to lemongrass oil for many purposes. Lemongrass oil is a relatively low-priced oil, however, so that the point at issue is whether or not Antigua would find its production to be profitable.

A New Sesquiterpene Hydrocarbon

Work has continued on the structure of the new sesquiterpene hydrocarbon, strobilanthene, which was isolated from the essential oil of *Strobilanthopsis linifolia* from Northern Rhodesia. Details of the isolation and preliminary work on the structure have already been published (W. S. Matthews and G. B. Pickering, *Industrie Chimique Belge*. Compte Rendue XXXIe Congrès International de Chimie Industrielle, Liège, Septembre 1958, **Vol. II**, p. 635). The hydrocarbon has a cadalene type of structure and yields cadinene dihydrochloride with hydrochloric acid. Preliminary examinations of this compound in which infra-red and ultra-violet absorption spectra have been an essential feature have indicated that part of its molecule might be structurally analagous to the monoterpenes sabinene (I) and α-thujene (II) in that an ethylenic linkage

I

II

is conjugated with a *cyclo*propane ring. Strobilanthene, sabinene and thujene all have ultra-violet absorption maxima in the region of 211 mμ, a wavelength somewhat greater than that shown by compounds containing single ethylenic bonds, but less than that normally associated with the simpler conjugated olefines. It is believed that this higher wavelength of maximum absorption is due to the conjugation of the *cyclo*propane ring with a double bond which is *exo*cyclic in the case of sabinene and *endo*cyclic in α-thujene. Thus, these studies, together with the evidence of infra-red absorption spectra, support the view that strobilanthene contains a *cyclo*propane ring with a conjugated *exo*cyclic double bond. Attempts at ozonolysis and other methods of degradation to yield identifiable products have proved surprisingly difficult, but some progress along these lines is now being made.

Gas Chromatography for the Examination of Essential Oils

All samples of essential oils which were received by the Institute were examined by gas chromatography in addition to any other type of examination which was necessary. Samples which previously would have been subjected only to a routine determination of the analytical constants were examined and their chromatograms compared with those of oils known to be of good commercial quality. This showed at once any peculiarity in the composition of the sample and was a good guide to its quality.

Useful information was obtained by comparing the chromatograms of the oils as received with those obtained after the oils had been treated with reagents which were specific for certain types of compound. For example the reaction

products remaining after the determination of the ester value, the carbonyl content by the hydroxylamine hydrochloride method, and alcohol content by acetylation, were used for this purpose. Most of the oils examined were treated in this way before any attempt was made to identify the individual components. Even when it was impossible to identify the components of an oil by gas chromatography alone, the information obtained by this technique was a useful guide to the planning of an analysis by older methods.

The possibility of determining the structure of the carbon skeleton of a terpene by hydrogenation followed by a comparison of the retention time of the product with those of completely reduced terpenes such as pinane, camphane, *p*-menthane, etc., is being investigated.

Gas chromatography has also proved to be useful in following the course of a fractional distillation, or the elution of a sample from an adsorption chromatography column, and in determining the purity of the material produced. It is being used in this way in an investigation of the structure of strobilanthene (see above), in the examination of the oil of *Tagetes minuta* and in the isolation of pure terpenes for use as standards in gas chromatography, infra-red and ultra-violet spectroscopy.

Since the nature of the stationary phase has a very great influence on the resolution of the components of a given mixture, a number of substances have been studied in order to assess their utility as stationary phases for the analysis of essential oils. As a result of these experiments squalane, benzyldiphenyl, and polyethylene glycol 400 were found to be very useful. Some remarkable separations have been achieved by means of polyethylene glycol 400. A chromatogram of geranium oil, for example, obtained by means of a column containing poly-(propyleneglycol sebacate) indicated the presence of 14 compounds, whereas the same oil on a polyethylene glycol column gave 24 peaks. Other oils have behaved in a similar manner.

Polyethylene glycol, however, is not very stable and cannot be used at temperatures above 100°C, which is too low for the analysis of oils containing sesquiterpene alcohols. There is thus a need for a more stable compound with similar resolving properties and a search is being made for such a compound.

A gas chromatography apparatus has been designed and constructed for operation on a preparative scale and preliminary trials are being undertaken.

OILSEEDS, OILS AND FATS

Bleachability of Palm Oil

Investigations concerning the difficulty of bleaching Nigerian palm oil, which were referred to in *Colonial Research*, 1958-1959, (p. 296) have been continued.

It was previously shown that Nigerian palm oil, prepared according to a method devised by the Institute in which oxidation and delay in processing were minimized, had excellent bleachability, generally superior to the best of the Malayan oil. It was also noted that the delay in processing which usually occurs in primitive extraction methods resulted in a major deterioration in the bleachability of the oil.

Further studies confirmed that delay in processing is one of the main causes of deterioration in bleachability and that this deterioration is associated with the presence of a lipoxidase in the fruit. When oils of good bleachability were treated with lipoxidase preparations obtained either from palm fruit specially flown to the United Kingdom or more conveniently from dried

haricot beans, considerable deterioration in bleachability occurred. This deterioration was irrespective of whether heat, bleaching earth, or combined heat and bleaching earth procedures were employed for the treatment of the oil, although the effects were most marked with bleaching earth. During oxidation there is a rise in the conjugated diene content of the oil and an increase in its peroxide value. However, enzymic oxidation evidently differs somewhat from atmospheric oxidation, as indeed has been shown by studies published elsewhere on the oxidation of methyl linoleate. The resultant methyl 13-hydroperoxy-octadeca-9: 11-dienoate and the methyl 9-hydroperoxy-octadeca-10:12-dienoate resulting from atmospheric oxidation were optically inactive, whereas those resulting from enzymic oxidation showed optical activity. This activity can be enhanced by reduction of the hydroperoxide when the resultant hydroxy acid has an activity similar to that of 12-hydroxyoleic (ricinoleic) acid, the main fatty acid constituent of castor oil.

Oxidation of the linoleic acid present in palm oil is accompanied by changes also in the nature of the carotenoids present. This was demonstrated by differences in the spectra of palm oils which were easy and difficult to bleach.

Evidence was also obtained to indicate that the colour remaining after the bleaching of an inferior oil is predominantly found associated with the fatty acid (which is coloured yellow). It was concluded that the cause of the difficulty experienced in bleaching Nigerian oil was due to coupled oxidation between the carotenoids and the unsaturated fatty acids present, resulting in the formation of coloured compounds, which are difficult to bleach. These could be due to the combination of oxidized fatty acids with the carotenoids or their decomposition products.

Meanwhile, it has been clearly demonstrated that good quality oil can be produced from Nigerian palm fruit if the speed of processing is rapid and undue heating and concomitant oxidation avoided. The West African Stored Products Research Unit is therefore experimenting in Nigeria with methods designed to apply these findings in practice and it is hoped that Nigerian oil of improved bleachability will result. One difficulty is to recover the increased processing costs by the sale of the improved quality oil in the United Kingdom market.

Nigerian oil has a relatively high carotene content, normally more than double that found in Malayan oil. When the oil is inefficiently processed the presence of this carotene is related to the appearance of chromogens associated with difficulty in bleaching. Hence the long term aim in Nigeria should be to breed palms yielding a light coloured oil.

False Ambergris

A waxy, yellowish solid found off the shore of Ngau, an island of the Fijian group, was suspected of being ambergris, an expensive commodity used in perfumery, but a preliminary examination of the very small sample submitted for valuation showed that this was not the case. Since its identification involved the application of reverse phase paper chromatography a description of the methods employed may be of some interest.

Extraction of the original material with solvents showed it to consist of 90 per cent saponifiable matter, whilst the remainder appeared to be mammalian connective tissue. The analytical constants of the fat determined by micro methods (Refractive Index, nD 40°C 1.465; Saponification value mgKOH/g

oil 186; Iodine value, (Wijs ½ hour) per cent, 22.1; slip point of the mixed fatty acids 57°C) were puzzling. Reverse phase paper chromatography was therefore applied to the fatty acids using substantially the technique described by Ballance and Crombie (*Biochem. J.* 1958, **69**, 632-640). The sample was found to contain about 60-70 per cent of a C_{18} hydroxy acid, 30-40 per cent of palmitic and/or oleic acid and traces of other acids. This finding was verified by the determination of the hydroxyl value of the sample, (160 mg KOH/g oil) and indicated that the fatty portion of the material was mainly derived from hydrogenated castor oil. This material and its main constituent, 12-hydroxystearin, are used extensively in the preparation of multi-purpose greases that combine high temperature stability with water resistance. It was concluded that the supposed ambergris was derived from a marine lubricant and that the fibrous matter became embedded in the fat after the latter was extruded into the ocean.

MICROBIOLOGY

A small microbiological unit has now been attached to the Oils Section but is not yet fully equipped. This unit should be able to make a valuable contribution to the elucidation of the importance of moulds and bacteria in the deterioration of oils and oilseeds during storage. However, the Unit is available for the more general work of the Institute and its first problem was a study of the retting of the coconut husk. This is briefly reported under "Vegetable Fibres".

FOODS AND FEEDING STUFFS

Rice

Work was carried out on West African rice in collaboration with the Federal Rice Research Station, Badeggi, Nigeria and the West African Rice Research Station, Rokupr, Sierra Leone.

Comparative analyses were made of red (*Oryza glaberrima*) and white (*O. sativa*) varieties of rice, obtained from the above mentioned research stations, to determine whether their composition differed in such a way as to make varieties of one species nutritionally superior to those of the other. The only major difference found was that the red varieties had a higher nicotinic acid content than the white, but it was unlikely that this difference would have any marked nutritional significance. It was thought that the higher nicotinic acid content of the red varieties might be due to the fact that the red grains had thicker pericarps, since the bulk of the nicotinic acid in rice is concentrated in this region.

As the result of reports by Indian workers that the protein content of rice could be related to the length of the sterile glumes, a survey of the protein contents of different varieties grown at the Federal Rice Research Station, Badeggi was started and is still in hand. The protein content of the staple cereal of the North Nigerian native diet is of considerable significance in connection with the widespread protein deficiency of the area. So far, no correlation between sterile glume length and the protein content has, in fact, been established for the varieties under investigation.

Coffee

Since the beginning of this decade the export of coffee from Sierra Leone has increased from a very small figure to around 3000 tons annually. As a result of the expansion in production, the authorities in Sierra Leone have been carrying out trials to determine the best conditions for harvesting and processing

the coffee. The Institute has collaborated in this work by furnishing reports on the quality and commercial value of numerous samples prepared by different harvesting and processing methods.

The Institute has also reported on the quality and commercial value of four samples of coffee from the Western Region, Nigeria. Two of these samples consisted of beans of *Coffea canephora* of the Quillou variety, and the other two consisted of beans of *C. canephora* of the Java variety. The beans of the Quillou variety were slightly superior in quality and, as this variety also gave better yields, it was recommended that it be grown in preference to the Java variety in the Western Region. Reports were also provided on samples of coffee from the Northern Region, Nigeria.

Cocoa

Comments on the quality and commercial value of two samples of cocoa beans were sent to authorities in Tanganyika. The flavour of the beans was poor and they tended to be brittle. Suggestions were made as to how the processing of the beans could be altered to improve their quality. Reports were also furnished on samples of cocoa beans from Jamaica and Ghana.

FRUIT AND VEGETABLE PRODUCTS

Naringin Crystals in Canned Grapefruit Products

It is known that deposits of naringin crystals are found from time to time in canned grapefruits products particularly when these are kept under cold storage. These white deposits are most unsightly and although harmless, lead the consumer to think that a mould is present. A high naringin content will also give an excessively bitter taste to the product. A sample was received at the Institute taken from a can of grapefruit segments, of which the naringin content was found by the Davies method to be 0.15 per cent. The matter was discussed with representatives of the canner and suggestions were made regarding modifications in the preparation of the fruit with a view to reducing the incidence of the trouble. With the co-operation of the Department of Agriculture concerned an investigation of this problem has started.

Pineapple Juice

Concentrated pineapple juice darkens in storage due to a "browning reaction" at temperatures above 0°C, but it is known that this development is inhibited in other products by the addition of appropriate quantities of sulphur dioxide. Following preliminary experiments, an investigation was started in which increasing amounts of sulphur dioxide were added to pineapple concentrate and the effects are being observed during storage at different temperatures. An investigation into the constituents of Malayan pineapple juice, particularly those affecting flavour, is proceeding.

Dates

Efforts are being made in the Eastern Aden Protectorate to develop the date industry. Little was known regarding the composition of dates produced in that country and the analysis of fruit of certain varieties was therefore carried out. This analysis showed that Aden dates have a similar composition to that of dates grown in other countries, and also confirmed the findings of Cavell (*J. Soc.*

Chem. Ind., 1947 **66**, 195-198) that fully ripe dates contain no sucrose. In connection with the development of date products in Tripolitania, the examination of date syrup was undertaken on behalf of the Libya Mission of F.A.O.

Bananas

The preparation of notes reviewing the present market position of fruit and vegetable products was continued. Although much of the output is for local consumption, it is estimated that bananas account for 40 per cent of the world trade in fresh fruit. In "A Review of the Marketing and World Trade in Bananas" prepared for Ghana, but given wider circulation, the production of the fruit was considered with reference to cultural and varietal considerations, and the development of the trade in exporting and importing countries. Following war-time and post-war dislocation, the banana trade has expanded to about 30 per cent above the 1938 position. Generally, there has been a fall in production in Central America and expansion in South America and parts of Africa, while a notable development has been achieved in the Windward Islands. Consumption per head in the United States has fallen, compared to the pre-war period, and is virtually unchanged in the United Kingdom but an important increase has been achieved in certain Western European countries. Consequently, it was concluded that the present outlook indicates no more than a modest growth in total world trade in the fresh fruit, while it was noted that the banana industry suffers through lack of important outlets in processed products.

Canned Pineapple

In the search for diversification in agricultural production in post-war years, too many countries turned to the production of pineapple. Before the war 90 per cent of the United Kingdom imports of canned pineapple were obtained from the Federation of Malaya and Singapore, but through the destruction and necessarily slow rebuilding of that industry, supplies were short for a period.

A note on "The United Kingdom Market for Canned Pineapple" was circulated, which reviewed the position during the latter half of the year. It was concluded that although consumption had increased, canning in newly producing countries such as Kenya, which had not previously supplied the British market, together with considerable expansion in the Australian and South African canned pineapple industries and the recovery of the Malayan industry, had caused the United Kingdom market to become oversupplied. The probability of increasing competition was forseen and it was apparent that some small producers might not be able to retain their position in the industry.

Frozen Fruits and Vegetables

Tentative interest has arisen in Kenya in the potentialities of a frozen fruit and vegetable industry and preliminary information regarding the organization of production and the type of equipment necessary was supplied. Regarding export prospects, it was pointed out that vegetables are the most important of all the frozen foods consumed in the United Kingdom and that, in addition to the expanding home production, imports, mainly of peas, have increased appreciably in recent years. It was emphasized that a good deal of investigational work would be necessary to establish an export industry. In particular the standard and quality of frozen vegetables imported into this country is very

high and technical production requirements are exacting, e.g. suitable varieties must be grown and processed at the correct state of maturity.

It was suggested that the production of frozen pineapple in Kenya might have possibilities although at present prices, increased supplies would meet strong competition from the cheaper canned product.

Citrus Pectin

A commodity of which the potential production is much in excess of world requirements is citrus pectin and a review of the present supply position was prepared for Cyprus; in existing circumstances development was not recommended. The present commercial sources of pectin are apple pomace, used in the United Kingdom, United States, and in other industrial countries and citrus peel waste of which world production is largely concentrated in one factory in California. Grade for grade and for many commercial purposes these pectins appear interchangeable. It was noted that even the Florida citrus processing industry does not attempt pectin production, but there is a small Italian industry. It was observed that the manufacture of citrus pectin has been widely discussed in many citrus processing countries but the process is expensive and complicated and the varying requirements of consumers favour the large producer. Generally, domestic needs have been judged to be inadequate to support such an industry while the world market for the commodity is adequately met by established producers.

Bromelin and Hesperidin

There are many references to these potential by-products of fruit processing industries and enquiries regarding the present prospects for commercial development were undertaken on behalf of Kenya and Cyprus. It was shown that there is, as yet, practically no United Kingdom commercial interest in bromelin, the proteolytic enzyme derived from pineapple, some production of which has been developed in the United States. A future possibility might be the manufacture of bromelin preparations from crude material produced overseas but so far no large demand was apparent for these in this country.

No important outlet was discovered for hesperidin, a flavone present in oranges and certain other varieties of citrus fruits; it is used to a limited extent in certain countries as a constituent of cold cure preparations. There is a small consumption in the United Kingdom for pharmaceutical purposes but no immediate demand of any consequence was anticipated. At present Japan is the main source of supply.

INSECTICIDES AND DRUGS

Insecticides

A very large volume of work was carried out on the determination of residues of insecticides on various tropical products, the examination of insecticidal powders, and in collaborative work on insecticide analysis. Residue determinations were made for the West African Stored Products Research Unit, the West African Cocoa Research Unit, the Tea Research Unit, Ceylon, and for other bodies. The more important determinations were: malathion in groundnuts (Nigeria), BHC in cocoa beans (Nigeria and Ghana), DDT in green and fired tea (Ceylon), pyrethrins—piperonyl butoxide in cocoa, and BHC in guinea corn (Nigeria).

Collaboration with the Expert Committee on Insecticides of the World Health Organization has continued; various samples of insecticide formulations have been examined and technical comments and information furnished in connection with the revision of pesticide specifications.

Aloes

Curacao type aloes, obtained from *Aloe barbadensis* Mill., are used for the production of the active purgative principle, aloin, which consists chiefly of the crystalline substances barbaloin (9(1)-deoxyglucosyl aloe-emodin anthrone) and *iso*barbaloin. As this type of aloes has for some years been very scarce and has commanded high prices, efforts have been made to develop production on some of the smaller West Indian islands where growing conditions were suitable. A small batch of aloes prepared recently in Antigua was examined and found to be very promising; in particular the product had a satisfactory aloin content of 23 per cent, and it was shown by paper chromatography that the aloin present was closely similar to commercial aloin. Trade opinions on the material were also favourable.

On another aspect of the matter, information on the inspissation of aloe juice was supplied to St. Kitts-Nevis-Anguilla, where other experiments in aloes production are in progress.

TANNING MATERIALS

A re-examination of *Anogeissus schimperi* bark from Western Nigeria, in comparison with samples previously examined, confirmed the view that, while the analytical constants of the extract vary considerably with conditions of environment and collection, the overall range of values for tannin content was, nevertheless, very low and the bark could, therefore, only be of value for local tanning where more suitable material was not available. Leaching and tanning trials which, in general, confirmed these findings, showed that the tannin complex of the extract varied over a wide range of molecular weights. The high molecular weight tannins were undesirable as they retarded the rate of tannin uptake by blocking penetration at the surface of the pelt. This action also resulted in the leather being very dark in colour and rather brittle and it might be necessary to remove the large molecular weight material from the surface of the leather immediately after tanning. The low molecular weight tannins were, however, capable of producing a satisfactory leather and the use of solvents to extract these preferentially was suggested as a means of producing a possible form of tannage. An alternative method, and one that might prove better suited to local conditions in Nigeria, was to use the ground bark with water in a simultaneous leaching and tanning process rather than carrying out the extraction and tanning separately. Although this method might be rather slow it has the advantage of being relatively simple and was apparently capable of producing a satisfactory leather.

VEGETABLE FIBRES

Surface Structure of Fibres

In order to supplement previous work carried out at the Institute on the identification of fibres of vegetable origin, an investigation was undertaken to study the surface structure of such fibres in various stages of mechanical and chemical degradation. A technique of surface replication and subsequent metal

shadowing of the replica was used, this allowing surface detail not normally observable under the microscope to be seen. In addition to providing information on the structure of vegetable fibres which will be a valuable supplement for identification purposes, it is hoped to use this technique to clarify the dependence of mechanical properties on histological structure.

Retting of Coir

Preliminary work was carried out for Dominica on the possibility of retting coir in fresh water and was supplemented by a detailed investigation by microbiological methods. The effect of soaking both dried and green husks in nutrient solutions of various compositions and strengths, saline solutions, etc., was investigated. The most promising results were obtained with fresh green husks which had been crushed before retting. The fibre extracted from these husks after 3 months' retting in nutrient solutions was of good colour, lustre and softness. It was found that ripe, stored husks could also be retted in three months in certain nutrient solutions under laboratory conditions but the fibre extracted from these husks was dull, of poor colour and of harsh handle. The experiments indicated that the extraction of the fibre from the retted husk takes longer in the case of stored than in fresh husks.

Musical Reeds

Considerable work has been carried out on the growing of *Arundo donax* in Jamaica. This cane is used for making reeds for musical instruments, and at present only those canes grown in the South of France are suitable for good quality reeds. Investigations into differences in histological structure of Jamaican and French canes have been started. By such work together with other physical test methods, it is hoped to determine the requirements necessary for good quality reeds. The eventual aim is to grow suitable canes in Jamaica for the American market.

Mechanization of Fibre Processing

The mechanization of the processing of fibre crops received considerable attention. Field trials were carried out on the ribboning of kenaf, and a small decorticator for the extraction of fibre from pineapple leaves was tried in East Africa. The possibility of using ultrasonic energy for the washing of fibres received some attention, and it is hoped to carry out trials in conjunction with commercial firms.

Agave Fibre

Fibre from a newly developed second generation hybrid of *Agave amaniensis* and *A. angustifolia* was examined. Differences in tensile strength, length and fineness were measured for the first three cuts and compared with *A. sisalana* grown at the same station in Tanganyika. Further measurements of these properties will be made for each cut until poling. A study of differences in morphological and histological structure of leaves and fibre is in progress.

PULP AND PAPER MAKING

British Honduras Timbers

The examination of the pulping characteristics of five hardwoods from British Honduras was completed. The woods concerned were *Ochroma lagopus*,

Schizolobium parahyba, *Heliocarpus donellsmithii*, *Cecropia peltata* and *Spondias mombin*.

The investigation fell into three parts. Firstly, each of the woods was pulped separately by the sulphate process. Secondly, the five woods were mixed and pulped together by the sulphate process. Thirdly, the mixed woods were pulped by two semi-chemical processes. Bleaching trials were made on both chemical and semi-chemical pulps from the mixed woods.

It was concluded from this investigation that these mixed hardwoods were capable of producing high yield semi-chemical pulps under comparatively mild pulping conditions. These pulps are also light in colour and might well prove useful as the major constituent in a newsprint furnish. The full report of this investigation will be published in the near future.

Pulping of Home Grown Timber

Work began in February on the pulping and pulp evaluation of home-grown Sitka spruce samples on behalf of the Forestry Commission. So far, 30 samples from six sites have been completed. Each sample was pulped by the sulphate process and the pulp evaluated by means of British Standard Sheet from 4 beating periods in the Lampen Mill. The results were then statistically analysed by the Forestry Commission so that the relationship between growth and pulping characteristics could be studied. This work is eventually to be carried out at the Forest Products Research Laboratory and a number of their staff have been trained for this purpose.

ECONOMICS DIVISION

During the period under review, 67 enquiries were received, of which 44 related to the marketing of various commodities, 4 were concerned with the establishment of new industries and 9 were of a general economic nature. 10 enquiries were of a purely statistical nature relating to statistics of production, consumption, etc., of various commodities. Over one third of the total enquiries were received from East Africa and the West Indies.

The Economics Division did not function as a separate Division until the beginning of 1959 and the recruitment of personnel, i.e. three members of staff engaged on statistical work and four economists, was not completed until towards the end of the year. The Division was formed primarily to relieve the technical and scientific staff in the Institute of work relating to the marketing and economic aspects of various tropical commodities and to provide statistical information not only for the Division itself but for the work of the Institute as a whole. During the year practically all the enquiry work relating to the marketing of products which was formerly answered by the commodity sections was taken over by the Division. Consequently, marketing problems accounted for over 65 per cent of the enquiries dealt with. The following are some examples of this type of enquiry:

The Institute was asked to consider the possibilities of marketing in the United Kingdom industrial alcohol produced in Mauritius from molasses. In view of the dominant position now occupied by synthetic alcohol from petroleum, it was not considered possible to recommend investment in new

plant for alcohol production by fermentation, particularly since at present a considerable proportion of the molasses produced in Mauritius is used as a fertilizer, part of which, at least, would have to be replaced by imports. There is moreover an established market for the molasses for feeding stuffs. Other factors which militate against any expansion of production of alcohol for export from Mauritius are the long distances from the markets, lack of a regular tanker service and the competition from other countries which are more favourably placed from the economic point of view.

Enquiries were made about the marketing of rum from Antigua in the United Kingdom. The survey showed that the heavier types of rum from Jamaica and Demerara dominated the United Kingdom market and that, for a variety of reasons, previous attempts to market light rum of the type produced in Antigua had not generally been successful. It was not thought possible to establish a market for a new rum of this kind under its own name without considerable expenditure on market development. Even with such expenditure, satisfactory results might not be obtained. The view was expressed, however, that light rum from Antigua might be suitable for blending purposes and larger samples were requested so that a fuller assessment of the qualities of the rum for blending could be made.

Small quantities of unwithered tea are produced in East Africa and a survey was made of the future prospects for such tea, which is used almost entirely for blending purposes, particularly for quick-brewing teas since it infuses quickly. Trade opinions regarding unwithered teas were found to differ considerably, partly because there is a wide variation in the quality of unwithered teas from different sources and partly because there is some prejudice against tea processed in an unorthodox way. However the opinion generally expressed by the trade was that good quality unwithered tea would normally find a market, but that the extent to which it can be used for blending will be limited by its bulk, taste and appearance. Although some unwithered tea from East Africa is equal in quality to unwithered tea from India and Ceylon, in general it is considered to be inferior. The enquirers were informed that although there seemed no likelihood at present of any great expansion in the market in the United Kingdom there might be prospects for expansion in some countries where unwithered tea is still not used or where its use is very limited, provided effective sales promotion methods were used.

Other marketing enquiries were concerned with beeswax, coffee, bêche-de-mer, kenaf and ramie fibres, turpentine and rosin, Burley tobacco, garlic, ginger, papain, cinchona, essential oils and various foodstuffs.

An important part of the Institute's work is to answer enquiries regarding new cash crops or products which might help to diversify the economy of a particular country or, independently, to advise tropical countries of commodities for which the market is expanding and for which a new source of supply would be desirable. Since castor is one of the crops which might be suitable for this purpose, a survey was made, in co-operation with the appropriate commodity section, of the world markets for castor seed and oil and of trends in the use of oil. The main obstacle to establishing a new source of castor oil in the United Kingdom market is the tendency of users to be chary of unfamiliar producer's areas and reluctant to change. Oil from new sources, therefore, would need to be very competitive in price and at least equal in quality to that from India, the main supplier to this country. New industrial applications for castor oil, particularly as a raw material for chemical manu-

facture, seem likely to expand the demand for the oil, and in the U.S.A., which is the largest single market for the oil, consumption is expected to increase considerably in the next ten years. At the same time, however, domestic production of the seed is being encouraged in the U.S.A., in order to make the country self-sufficient. The future world market for new supplies from other sources will therefore depend considerably on the progress of domestic production of the seed in the U.S.A.

The Southern Cameroons were interested in growing alternative export crops to bananas and one crop considered was kenaf fibre (*Hibiscus cannabinus* L.), a jute substitute. Enquiries showed that there would be a market in this country for good quality fibre provided that regular supplies could be offered at prices competitive with jute. It was stressed that proper grading of the fibre before shipment would be essential so that the standard of quality could be maintained. The suggestion was made that if commercial production were undertaken in the Cameroons the possibilities of finding a market for the fibre with the sack factories in Kenya, Southern Rhodesia, and the Union of South Africa might also be explored.

As development proceeds in various tropical countries there is invariably a desire to establish small industries which can make use of locally produced raw materials and process them either for export or for sale locally in order to reduce imports. Thus, enquiries were dealt with concerning the setting up of a small plastics industry, a match factory, a button industry and a rubberized coir industry. Advice on the establishment of small industries such as these will probably become one of the more important functions of the Economics Division.

Requests were received during the year from two East African countries for economists to be seconded to them for work in connection with surveys of local markets and for studies in farm economics. With the present small staff of the Division secondments for periods as long as twelve months or more are obviously impossible but it is appreciated that, as the Division expands, provision will need to be made for staff for work of this nature. It will also be necessary to send staff overseas to study the market requirements and conditions for raw materials of tropical origin, particularly those materials where the main markets are normally in non-European countries.

With the Division's recent creation and the consequent extension of the Institute's activities into the economics field, it has been necessary to build up a collection of economic literature and indexed information comparable to that which already exists to serve the scientific divisions. A good deal of time during the year was devoted to this task. Contact was also established with other organizations working in closely related fields, such as the Stanford Research Institute (U.S.A.), the International Co-operation Administration (U.S.A.), The Commonwealth Economic Committee, and the United Kingdom Social Survey.

RESEARCH DIVISION

The Research Division of the Institute has only recently been formed and is not yet full staffed. Its activities can be described in broad terms as the study of the chemistry and physics of natural products, from which it is hoped to secure their more effective utilization.

In addition to the researches carried out at the Institute others, with the financial assistance of the Department, are being conducted extra-murally at various universities and colleges within the Commonwealth.

The Division consists of five sections whose individual duties are: the study of the organic chemistry of natural products; the preparation and examination of surface-active materials based on sugar (sucrose); the study of naturally-occurring insecticides; the examination of plants possessing physiological activity and the isolation and study of their active principles; and physico-chemical studies of plants and other natural products. The section dealing with the organic chemistry of natural products is not yet adequately staffed for the work which has been mapped out for it.

SURFACE-ACTIVE AGENTS DERIVED FROM SUGAR

The potential world production of sugar is at present far in excess of requirements so that it has been necessary to limit, by agreement, the level of exports from the sugar-producing countries. This has seriously disturbed the economy of these countries, and especially of those countries where sugar production was practically the sole means of livelihood of their people.

Virtually the whole sugar production of the world is consumed as food yet sugar has a number of attractive features which should commend it to industry for exploitation. The present investigation is being supported financially by the United States from funds made available under Public Law 480 administered by the U.S. Department of Agriculture. The terms of the contract define the work as being directed towards the production of materials, based on sugar and naturally-occurring fatty acids, which have surface active properties. If such materials could be made with properties comparable with existing commercial detergents and competitive in price, they would find a wide field of applications as they would be non-toxic and also readily decomposed during the normal sewage disposal processes.

A number of papers and patents have already appeared which describe the preparation of sucrose esters such as the oleates, palmitates, stearates, etc., by interacting the sucrose with an ester, such as methyl stearate, in homogeneous solution in the presence of an alkaline catalyst.

PHYSIOLOGICALLY ACTIVE SUBSTANCES FROM PLANTS

The use of plants and plant extracts for the treatment of disease has been practised for so long that there now exists a vast store of information on the topic. The scientific sifting of this information is, however, such a tremendous task that it is never likely to be carried out completely, and it is, therefore, customary to select certain facets for detailed study.

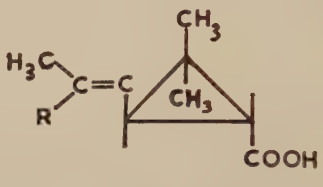
This section, which has only recently come into being, is studying publications and other information relating to local medicines in various Colonial territories and plants are being selected for examination which are reputed to be of value in the treatment of mental disorders, or which affect blood pressure.

Various extracts of these plants will be made and submitted to the Institute's Pharmacological Testing Unit, Birmingham University (see p. 25) for examination of biological activity. On the basis of this examination certain plants will be selected for more detailed study and their active principles isolated and characterized. Structural studies will be made of any substances isolated which possess outstanding value and whose constitution is unknown.

Investigations, started before the formation of this section, continued on plants suspected of containing steroidal sapogenins. Particular attention was paid to diosgenin-containing *Dioscoreas*, and as a result of an earlier trip by Dr. S. Bampton to British Honduras to search for new sources of diosgenin, a trial plantation of a *Dioscorea* sp. found there is being set up in the territory to determine the possibility of its introduction as a new cash crop.

NATURALLY-OCCURRING INSECTICIDES

The insecticidal activity of pyrethrum extract is considered at present to be due to the presence of four unsaturated esters which are derived from two acids, chrysanthemic acid (I,R=Me) and pyrethric acid (I,R=COO.Me), and two alcohols pyrethrolone (II,R= $-CH_2-CH=CH-CH=CH_2$) and cinerolone (II,R=$CH_2-CH=CH-CH_3$).



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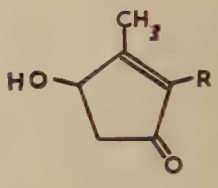


II

The two esters derived from the combination of chrysanthemic acid with pyrethrolone and cinerolone are called pyrethrin I and cinerin I respectively, and the two esters from pyrethric acid and the two alcohols are called pyrethrin II and cinerin II. The methods of chemical analysis of pyrethrum extract in current use are based on the assay of the two acids and no attempt is made to determine the relative amounts of cinerins and pyrethrins. The value of the material, however, resides in its insecticidal potency but until the relative toxicities of these four esters, alone and in admixture, are known it is impossible to predict whether or not the existing analytical methods will give a reliable guide to this property.

Attempts have been made in the past to determine the relative toxicities of these esters but conflicting results have been obtained by different workers. This lack of agreement was due to at least two causes. First, the difficulty of preparing pure samples of the esters; indeed, it is now known that the methods used for some of the earlier preparations could not have given pure materials. Second, the great difficulty that has been experienced in the accurate bioassay of insecticides. In the present work the biological testing has been done by Dr. R. Sawicki at the Rothamsted Experimental Station using five- to six-day-old female house-flies as test insects. They were treated topically with a 1 μl drop of solution in acetone, and examined for mortality after 24 hours at 20°C.

Previous workers had already shown that small quantities of the four esters could be separated by displacement chromatography on alumina. In the present investigation, eluates obtained from three different samples of commercial pyrethrum extract using this type of chromatographic column were examined for biological activity and chemical and physical properties, e.g., infra-red and ultra-violet absorption spectra and characteristic reactions with phosphoric acid and Denigé's reagent. The results strongly suggest that the insecticidal activity of pyrethrum extract is due solely to the pyrethrins and cinerins. Since the proportions of these four esters in the pyrethrum extract can be determined

from the chromatographic analysis, it is possible to reconstitute the original extract using the pure cinerins and pyrethrins. Solutions prepared in this way corresponding to the three different extracts were tested biologically and found to be identical with the original extracts. These results confirm that within experimental error all the insecticidal activity of pyrethrum is due to the pyrethrins and cinerins and indicate that no natural synergists are present in the commercial extract.

The relative toxicities of the four esters, prepared by chromatography, were found to be, at the lethal dose (LD) 50 per cent level, pyrethrin I, 100; pyrethrin II, 130; cinerin I, 40-50; while cinerin II, which was present only in small amounts appeared to have a similar value to cinerin I. Preliminary studies also indicated that mixtures of these compounds have a toxicity which is the sum of the toxicities of the separate components and consequently they possess no mutual synergism. There are indications that the relative toxicities vary with the technique of application and the solvent used.

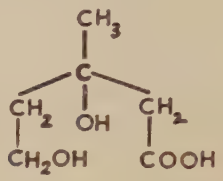
This information is not only useful for analytical purposes but can also be of value to the plant-breeding programme in Kenya. Thus, the results suggest, insofar as toxicity is concerned, that is would be sufficient to breed for high pyrethrin content and to pay less attention to the ratio pyrethrin I/pyrethrin II which has been considered to be so important in the past. But a characteristic of the insecticide which is equal in importance to the toxicity is its rapid "knock-down". It was considered that techniques where the insects are anaesthetized or chilled to immobolize them for treatment were not reliable for assessment of knock-down. A new technique was therefore devised whereby the flies were attached to a terylene gauze by suction and then dosed. The fate of the dose under the airflow conditions of test was studied under U.V. light using acetone, "Cellosolve" and odourless kerosene containing fluorescent dyes. Kerosene spread very rapidly over the body of the insects, while the other solvents evaporated rapidly.

Using this technique it was found possible to assess the knock-down of fully active houseflies 15 minutes or less after dosing.

A study has been started of some aspects of the biochemistry and physiology of the pyrethrum plant to provide further information of value both to the plant-breeding programme and farming practice in Kenya. A part of this work has involved feeding compounds labelled with C^{14} to isolated pyrethrum flowers. It has been found, as might have been expected from previous work on terpene biosynthesis, that labelled acetic acid is incorporated into pyrethrin I and pyrethrin II. Further, the pyrethrin II molecule has been split and it has been found that both the acidic and alcoholic moities are labelled.

The labelled acetic acid can be fed to the flower through the stem, or by placing the radioactive solution containing a little detergent directly on the disc florets of the open flower. However, the best method for incorporation is to impregnate the isolated ovules of the flower. This suggests that the ovule is the most active site for the synthesis of pyrethrins in the flower head. It has also been shown that ovules dissected from unopened, and therefore non-fertilized, disc florets synthesize pyrethrins as effectively as those from opened disc florets and may even surpass them.

In recent years it has been found that a common precursor in the biosynthesis of terpenes and steroids is mevalonic acid (III), which on decarboxylation and dehydration gives isoprene.

III 

It is of interest to determine whether this compound is incorporated into the pyrethrins. By feeding experiments similar to those described above, it has been shown that 2-C^{14} mevalonic acid is incorporated into pyrethrins I and II. An attractive biochemical route to the rather unusual *cyclo*pentenone ring of pyrethrolone and cinerolone would be by the cyclization of mevalonic acid. This reaction would be novel in that the carboxyl carbon atom would be retained whereas in all other cases it is lost by decarboxylation to give the isoprene skeleton. It was found, however, that 1-C^{14} mevalonic acid fed to isolated ovules gave pyrethrins totally devoid of radioactivity and consequently the postulated reaction could not have taken place. Since it had been established that acetic acid is incorporated into the pyrethrolone ring under these conditions, it is clear that this compound is being synthesized during the course of the experiment. An alternative possibility is that this five-membered ring is an oxidation product of a more complex system which is made up of isoprene units. This possibility is at present being investigated.

A study has also been made of the distribution of pyrethrins in mature pyrethrum seed. It has been found that fertile seeds contain five to ten times as much pyrethrins as infertile seeds do and that the majority of this is contained in the ovary and only little in the husk. The observation that infertile seeds contain little pyrethrin is interesting because, as mentioned above, the ovules of unfertilized disc florets are actively synthesizing pyrethrins. The fate of this pyrethrin content on ripening and drying is as yet unknown. The experiments with labelled compounds have shown that fertilization is unlikely to be a large factor in pyrethrum production if the flowers are gathered before they are "over-blown"; this is in accord with current practice. The reverse conclusion might have been drawn from experiments on the examination of pyrethrum seed.

PHYSICO-CHEMICAL STUDIES

This section differs from other sections of the Research Division in that much of its activity is associated with problems which are being examined from other angles elsewhere in the Institute. One such problem concerned the determination of piperine in alcoholic extracts of black pepper (*Piper nigrum* L.) which was carried out conveniently using ultra-violet absorption spectroscopy. An essential preliminary to this operation was the isolation of pure piperine for the preparation of the calibration curve. Piperine prepared by the alcoholic extraction of the crushed fruits of *Piper nigrum* L. is known to be contaminated by its vinylogue (7-(3:4-methylenedioxyphenyl)-hepta 2:4:6-trienopiperidide) usually called piperettine.

Piperine and piperettine are readily distinguishable in the pure state by their ultra-violet absorption spectra, the maximum absorption of the former occurring at 345 mμ, and of the latter at 364 mμ.

The purification of piperine was achieved by successive recrystallization, its progress being checked by following the ultra-violet absorption and by using the molar extinction coefficient as a criterion of purity.

Infra-red absorption spectra played a very valuable part in the characterization of the pyrethrins and cinerins present in pyrethrum extracts, and they were also used with success to confirm the presence of diosgenin in chloroform extracts of kernels from *Balanites orbicularis*.

An indispensable requirement for all work employing infra-red absorption spectra is the availability of an adequate library of spectrum patterns. A start has been made in the building up of a collection of spectra relating especially to those types of substance which are of particular interest to the Institute. This involved the rigid purification of the various substances to a degree well beyond that normally associated with these materials. So far, the infra-red absorption spectra have been recorded of pinene, α-thujene and sabinene, all of which were purified by column chromatography. In addition the spectra have been recorded of a number of substances of more general interest and which are already well known.

Considerable attention was paid to certain aspects of plant nutrition. For example, the Sisal Research Station, Tanganyika has, for some time, conducted growing trials of sisal using various types and amounts of plant nutrients applied at different periods of growth, etc. It is clearly of the greatest importance in this work to know to what extent the plants were able to utilize these dressings, and determinations of potassium, calcium, magnesium and manganese, using the Lundegardh flame technique were carried out on samples of sisal leaves submitted by the Sisal Research Station. Assistance was also given to the Coffee Research Station, Kenya, who are particularly interested in the uptake of certain metallic elements in trace amounts by coffee plants. It is well-known that plants absorb from the soil a number of elements which, although taken up in only very small amounts, nevertheless play an essential part in their metabolism. Determinations of such elements in appropriate parts of the plants provide an excellent check on the incidence of disturbances in their assimilation.

When determinations of trace elements in organic materials are being made, it is necessary to effect a preliminary concentration by destroying the organic matter. This is commonly achieved by dry-ashing which, although convenient, needs careful control. In the work on coffee leaves, a wet oxidation using nitric acid was used to destroy the organic matter and to give solutions suitable for the spectographic determinations of copper, manganese, iron, molybdenum, zinc and boron. It was found, however, that a small amount of waxy material survived this oxidation procedure and that its presence in the solutions, together with the larger inorganic constituents, reduced the accuracy of the determinations. Study is therefore being made of procedures which involve a supplementary oxidation to destroy this wax-like material, or which attempt to separate the trace elements from it. In this latter connection, ion exchange and solvent extraction techniques are being examined as well as coprecipitation methods.

In this work it has been considered advisable to analyse a range of samples by an independent method. This was done by using a modified precipitation technique, followed by the final determination of the trace elements polarographically.

ADMINISTRATION AND DEVELOPMENT DIVISION

DEVELOPMENT

A new Development Section was created during the period under review and was partially staffed by the end of it. Its function is to examine the results of investigations in the Institute and elsewhere and to select from them ideas which might lead to valuable new products or processes for tropical areas. Where appropriate the Section will then carry out pilot scale examination of the selected projects or, alternatively, may encourage other organizations with suitable facilities to do so.

The Section's attention so far has been directed into three main lines:

1. *The Extraction of Protein from Tropical Vegetation.* A survey of current methods for the extraction of vegetable protein has been made. If economic considerations show it to be justifiable a practical examination of the most promising, using certain of the more readily available tropical plant materials, will be made.

2. *Utilization of Solar Energy.* An experimental flat plate collector was set up on the roof of the Institute building to study the effect of plate design, plate surface, type of cover and spacing, turbulators, throughput rates, etc., and to afford experience of solar water heating generally. The collector was designed to hold three separate collector plates measuring 6ft. by 2 ft., so that a direct comparison could be made between different collector plate designs. Water circulation is by means of a pump operated on a closed system and a 12-line continuous recorder has been installed to study temperatures at various positions in the collector.

An examination of air heating is planned along similar lines as a preliminary to the investigation of the possibilities for artificial crop drying by solar means.

3. *Bonded fibre mattresses.* Some tests have been carried out on the production of resilient bonding compositions from naturally occurring products. Although no satisfactory compositions have yet been obtained, some show promise. Samples of natural rubber, synthetic rubber and plastic latices were obtained and some small scale tests of fibre bonding carried out. Coiling of coconut fibre is being examined and modification of the fibre by chemical means will be considered. Investigations of the influence of coil diameter, modification of the fibre, nature and quantity of the bonding agent, etc., will be continued.

ADMINISTRATION

Finance and Accounts

With the transfer of the Tropical Products Institute to the Department of Scientific and Industrial Research on 1st April, the general administration of the Institute had to be reorganized to bring it into line with the finance and accounts practice of the Department.

Staff

The twofold expansion of the Institute's staff, which started in April, 1958, was nearing completion at the end of the period under review. In the non-industrial grades, twenty-one appointments were made to the Scientific classes,

10 to the non-Scientific classes; 6 appointments were made to the Industrial grades. Only 6 Scientific and 4 non-Scientific posts remain to be filled. Five vacation students were employed for periods of about two months during the summer.

Library

The Library now has a total stock of some 150 000 items, this figure including bound journals, textbooks and a miscellaneous collection of pamphlets, reports, etc. Approximately 1000 periodicals are currently received in the Library. Very broadly the subjects covered are tropical agriculture, forestry, and the production and utilization of the raw materials in the Colonial, Commonwealth and other tropical territories. There is also a comprehensive collection of publications from the United States Department of Agriculture.

Work has been proceeding during the year with the classification and recataloguing of the library stock. In addition to the author and classified catalogues now in preparation, an extensive card index to the periodical literature is maintained.

The Library is open for reference purposes to specialist members of the public from 10 a.m. to 5 p.m. Application should be made to the Librarian.

SCIENTIFIC LIAISON

A special section is responsible for publicity, patents, technical reports and papers, contact with other scientific bodies and organisations, seminars, collection of plant material for research workers and liaison in the field of phytochemistry, tabulation and determination of the Institute's effort, and the administration of the Institute's extramural activities at Universities and Colleges.

Publicity

Now that the Institute has almost attained its full complement of staff, efforts are being made to publicise its work more effectively. This presents certain difficulties as the areas in which publicity is most needed are the underdeveloped tropical countries. A start has been made and, with the co-operation of the D.S.I.R. Headquarter's Publicity Section, two broadcasts about the work of the Institute were made on the B.B.C.'s Overseas Service and a brochure on the Institute is almost ready for circulation.

Visits overseas by officers from the Institute still provide one of the best means of publicity however and it is intended that the number of these be increased. Visits made during the period covered by this report are given in Appendix I.

Plant Samples and Phytochemistry

The service of providing plant material for research work was continued, and, during the period of the report, material was supplied to thirteen universities or colleges, the Medical Research Council, pharmaceutical firms and to sections within the Institute itself. Research outside the Institute on these plant materials includes investigations on the chemistry of plants with reputed insecticidal effects (Dr. L. Crombie, Chemistry Dept., King's College, London), on the triterpenoid constituents of the latex of *Ganua* spp. (Dr. W. Laurie, Chemistry Dept., Royal College of Science and Technology, Glasgow), on the fluorine containing constituents of *Dichapetalum toxicarium* (Sir Rudolph Peters,

Biochemistry Dept., Institute of Animal Physiology, Oxford) and on the hepatotoxic activity of pyrrolizidine alkaloids (Dr. R. Schoental, Toxicology Research Unit, M.R.C.).

Literature Survey on Uses for Bark

A survey of the literature on bark, with particular reference to the bark of trees grown in Britain, its properties and uses, was undertaken for the Forestry Commission to assist in their endeavour to find an economic outlet for this material. In Britain bark is at present either burnt or completely wasted except for the small quantity of oak bark used in tanning and the bark which is incorporated in building boards manufactured from unbarked timber. In N. America, the vast quantities of bark thrown up enable its use as a fuel to be a profitable outlet, and the physical and chemical separation of various fractions is also an economic possibility. The survey suggested that neither of these outlets was likely to be applicable with the much smaller quantities of bark available in this country though it was proposed that further research should be undertaken in certain directions, particularly into the possibilities of producing charcoal, mulches and composts, building boards, and phenolic adhesives.

EXTRA-MURAL ACTIVITIES

The following are reports on extra-mural work being carried out for the Institute.

Natural Products Research Unit in the Department of Chemistry, University College of the West Indies

Studies on the Constituents of some West Indian Plants

Dr. R. J. Plimmer and Dr. E. V. Ellington have now joined Dr. K. E. Magnus and brought this Unit, under the supervision of Professor L. J. Haynes, up to strength.

With the object of finding new pharmacologically active substances, and also establishing the toxicity of certain local plants, a survey of the literature relating to poisonous and medicinal plants of the West Indies was made and a short list prepared of those considered worthy of examination. Standard extracts of 32 plants have so far been submitted to pharmacological testing and as a result of these tests three plants are being examined further.

The aqueous extract of a West-Indian plant is a powerful hypotensive agent when administered intravenously in the dog, and this activity was shown not to be due to the concentration of oxalate ions present. By preparative chromatography a material was obtained which was pharmacologically estimated to be much more active than dopamine, but only having one third to one half the activity of nor-adrenaline. The material contained traces of ninhydrin positive material, was highly unstable and behaved in colour and other tests in a manner more comparable with nor-adrenaline than with DOPA, dopamine, epinine and adrenaline. Paper chromatography indicated that DOPA and dopamine might also be present in the crude extracts.

Stachytarpheta jamaicensis. This was reputed to contain a glucoside and is used in folk medicine for a variety of purposes, including the control of high blood

pressure. Standard extracts proved toxic to rats and appeared to contain both pressor and depressor substances. The pressor component was found to be unstable and difficult to purify by chromatography without loss of activity, while the depressor component though more stable and not subject to loss of activity in chromatography was less evident in fresh extracts, indicating that it might be a decomposition product, or masked by the pressor component. The factor responsible for toxicity has not been studied in detail but appeared to be greatly reduced by drying of the plant material.

Pluchea odorata. While showing no activity in standard extracts, *P. odorata* or the related plant *P. purpurescens* have been reported as responsible for a case of poisoning with hallucinations. Extracts with 3 per cent aqueous tartaric acid or with methanol and 10 per cent ammoniacal methanol caused the internal haemorrhage and death of rats. Extracts appeared to contain no alkaloids, but in view of the hospital report samples are to be tested further, particularly for hallucinogens.

An examination is being made of the purple pigment of the local St. Vincent Yam (*Dioscorea* sp.). The pigment fades on exposure to light, changing through brown to red and has a U.V. absorption spectrum showing peaks at 545 and 280 mμ. It has been tested and examined for anthocyanins, but while the results indicated pelargonidin they were not sufficiently conclusive and further studies are to be carried out on more purified material.

Mr. N. McG. Philip attached to the Unit whilst working for a Ph.D. degree, has continued his investigations on *Phorodendron Wattii* (mistletoe) and began work on *Persea gratissima*, the Avocado Pear.

Phorodendron Wattii. The hypertensive activity of aqueous extracts of the leaves was shown by chromatography to be due to tyramine, the phenylethylamine nucleus being known to confer pressor activity.

Persea gratissima. Aqueous extracts of Avocado Pear leaf were shown to have a fairly prolonged hypertensive effect and isolation of the active principle has been attempted. Alkaloidal extraction followed by column chromatography of the crude base yielded an alkaloid-containing oil. Analyses and spectroscopy of the picrate and perchlorate of the base indicated an empirical formula of $C_9H_{17}NO$ with one carbonyl and a primary amino-group, corresponding to one unsaturation or one ring.

Mr. J. I. Henderson completed his work for a Ph.D. thesis on homonataloin, isolated from Natal aloes. His experiments suggested that like the known barbaloin, homonataloin is a C-glycosyl derivative of a substituted anthrone with the formula: (Fig. 1).

Preliminary experiments were carried out on the three components extracted in each case from Curacao aloes, Cape aloes and the dried juice of *A. candelabrum.*

Birmingham University, Department of Pharmacology

Pharmacological Testing Unit

Pharmacological investigations were made on plant extracts submitted by the Natural Products Research Unit, University College of the West Indies, the Tropical Products Institute and the Department of Chemistry, University College of Swansea. The tests included acute toxicity tests and subsequent

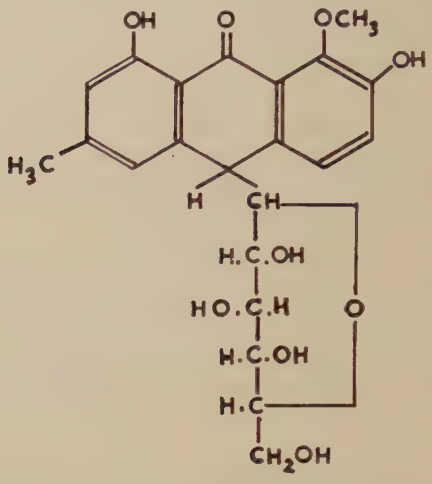


Fig. 1

determination of mode of action. In addition each extract was also tested on a range of standard isolated organ preparations, and other tests were carried out where special indications suggested them.

Of the extracts from the Natural Products Research Unit, six were selected as worthy of further examination. Four caused paralysis, this being correlated in two of them with an effect on the neuromuscular junction and in one with an effect on the isolated heart. Two other extracts were found to have a very marked "adrenaline-like" effect on the isolated heart, one of them causing an initial rapid lowering of blood sugar level.

The examination of extracts from the Tropical Products Institute and University College, Swansea is still in progress.

Tests have now been completed on the toxicity of "Comirin", a fungicidal antibiotic discovered at the Colonial Microbiological Research Institute, Trinidad. Owing to its haemolytic action Comirin has not been used clinically, but its activity against fungi has led to its consideration as an antimould agent in paints. The toxicity tests gave completely negative results for oral toxicity and skin sensitizing action.

Mr. B. E. Leonard has joined Dr. H. S. A. Sherratt in the Unit and is initially concerned with developing methods for pharmacological analysis with a view to applying them to those substances requiring detailed examination.

Makerere College, Uganda, Department of Agricultural Engineering

Methane Fermentation

Mr. W. Boshoff continued his experiments on the production of methane from organic waste materials. In batch experiments with elephant grass using either cattle dung or liquid from a daily-fed pilot plant as "starter", he examined the following aspects:

(i) The effect of time of year at which cattle dung is collected on gas production. A mixed sample of fresh and old cattle dung, collected at random from a cattle pen, was found to have the same "starting" qualities regardless of the time of year that it was collected.

(ii) The effect of ratio of dung to elephant grass. For successful starting of a methane fermentation the minimum ratio of dung to elephant grass on a dry weight basis was found to be 2 to 1. For optimum rate of digestion the ratio was found to be 3 to 1.

(iii) The effect of agitation on yield. Daily agitation of a daily-fed pilot plant resulted in a 25 per cent increase in gas yields.

Laboratory studies are continuing to determine the optimum feeding point of elephant grass to the starter dung. At present results indicate that a marked increase in the rate of digestion will occur when it is fed to the dung after digestion of the dung itself has commenced.

Experiments are also in progress to determine the optimum feeding point when using liquid from a fermentation previously started from dung.

Makerere College, Uganda, Department of Chemistry

Investigations of Steroid and Triperpenoid Constituents of East African Plants

Constituents of tea leaves and seed. Dr. W. J. Peal has concluded his work on the constituents of the unsaponifiable portion of the lipid fraction of tea leaf and tea seed. He showed the sterol to be α-spinasterol, the other major constituents being a saturated wax hydrocarbon mixture (C_{29} dominating), and a saturated wax alcohol mixture (C_{30} dominating). β-amyrin was detected in small quantities.

Dioscoreas. Several expeditions were made with the object of finding *Dioscorea* having a high content of diosgenin. A species not hitherto obtained was collected but was found not to contain any sapogenin.

Balanites. A sapogenin, possibly yamogenin, was isolated from the fruits of *B. wilsoniana*, and other species are being collected for investigation.

Acid Catalysed Dehydration of Steroid alcohols and related compounds

Following earlier work on the conjugative and stereochemical factors affecting acid catalysed dehydration of diosgenin and other C_3 hydroxy steroids, preliminary studies of the kinetics of the reaction were put in hand. Acid catalysed dehydration studies on aromatic alcohols were discontinued when it was found that α-(p-chloraphenyl) isopropyl carbinol did not undergo dehydration in aqueous acid.

University of Hong Kong, Department of Chemistry

Chemical Investigation of Local Plants

An assistant has been provided for Dr. H. R. Arthur to help with the investigation of alkaloids and other compounds of possible interest in plants collected in the main islands of the Colony and from the New Territories.

University College, Swansea, Department of Chemistry

Greenheart Alkaloids

The contract providing an assistant for Professor C. H. Hassall terminated in September. By that time the gross alkaloids from Greenheart (*Ocotea rodiei*) seeds had been extracted and largely fractionated, two crystalline compounds

of the bisbenzylisoquinoline group being isolated from the ether soluble fraction. The alkaloid fractions are at present being investigated by the Pharmacology Unit at Birmingham.

Birmingham University, Department of Chemistry

Chemical and Biochemical Syntheses of New Antibiotics Containing Amino- and Deoxy-Sugars

Mr. M. C. Keith continued his work under the supervision of Dr. S. A. Barker and has accumulated a stock of methylnovioside by acid hydrolysis of the antibiotic novobiocin. This will be used in attempting the synthesis of new disaccharides by growing microorganisms in the presence of methylnovioside, and disaccharides such as maltose, cellobiose or lactose.

Structure of Oligosaccharides obtained from Chitin and by Synthesis

Mr. J. G. Featherstone under the supervision of Professor M. Stacey is investigating the degradation of disaccharides containing amino groups with the object of determining the points of union between the monosaccharides. Particular attention has been focussed on the method for disaccharides containing a 1-4 linkage.

Leeds University, Department of Leather Industries

Constituents of Mangrove Bark and Related Vegetable Tanning Materials

Mr. T. Dalzell continued his investigations under the supervision of Professor A. G. Ward and Dr. H. E. Nursten. Recent work has been directed towards the separation, identification and quantitative estimation of the anthocyanidins derived from mangrove (*Rhizophora mucronata*) extracts. A study of the conditions and rate of production of anthocyanidins by a number of acids was made and the separation of anthocyanidin fractions on polyamide ("Perlon") columns was investigated and a satisfactory experimental technique evolved. Various methods of purifying the fractions so obtained were attempted and purified fractions examined by paper chromatography and spectrophotometry.

Bristol University, Department of Organic Chemistry

Strychnos toxifera *Alkaloids*

Mr. D. A. Yeowell continued his investigations under the supervision of Dr. A. R. Battersby. Several alkaloids were isolated and purified and attempts are now being made to elucidate their structure. One of the alkaloids is almost certainly xanthocurine.

Forest Products Research Laboratory, Princes Risborough

Preparation of Hardboard from Colonial Timbers

Board making experiments were carried out on four species of timber grown in North Borneo, Kapur (*Dryobalanops* sp.), Keruing (*Dipterocarpus* sp.), Red Seraya (*Shorea* sp.), and White Seraya (*Parashorea plicata*). Satisfactory hardboards according to the current British and U.S. Federal Standard Specifications were made on an experimental scale from each of the four species

and from a mixture of two of them. After treatment of the wood chips in a laboratory Asplund Defibrator no further refining of the fibre or additions of water-proofing or bonding agents were found to be necessary. The required strength and water resistance properties were obtained by a suitable choice of conditions in the press followed by hot air treatment of boards. In some cases the production of Super Hardboards, according to the above Specifications, was found to be possible by these methods.

R. A. E. GALLEY,

March, 1960 *Director.*

APPENDIX I

VISITS OVERSEAS

Dr. R. A. E. Galley, the Director, visited research establishments in East and West Africa in October and November. The organizations and people visited included the new factory and laboratories of the Pyrethrum Board of Kenya; The East African Industrial Research Organization; Makerere College, Kampala, where the Tropical Products Institute has placed two extra-mural contracts; the Colonial Pesticides Research Unit, Arusha, Tanganyika; the University College of Rhodesia and Nyasaland, Salisbury; the World Health Organization Regional Office at Brazzaville, French Equatorial Africa; The Permanent Secretary, Ministry of Food and Agriculture, Ghana; West African Research Office, Ghana; Ministry of Health, Ghana; Agricultural Development Corporation, Ghana; the Executive Secretary, National Research Council, Ghana; West African Cocoa Research Institute, Tafo, Ghana; The University College, Ibadan; The West African Council for Medical Research and the Malaria Service of the Federal Medical Department, Yaba, Lagos; the Federal Institute of Industrial Research, Lagos.

At the World Health Organization Regional Office, Dr. Galley took part in a symposium covering four important aspects of disease vector control, leading the section dealing with the chemistry, specifications and application of pesticides.

Mr. T. A. Oxley, the newly appointed Assistant Director in charge of the Advisory Division, visited Cyprus in September. He advised the Cyprus Grain Commission on the proper management and maintenance of their novel air-tight grain storage bins and recommended extension of the system to wheat storage in Nicosia. He also collected a number of problems—concerned, for instance, with the citrus industry and its products, carob beans, tanning materials and food standards legislation— which the Institute was later able to answer. The fact that the services of the Institute would continue to be available to Cyprus after the assumption of independence was stressed.

Mr. A. E. Chittenden, head of the Pulp and Papermaking section visited East Africa during April and May in connection with investigations of the use of sisal fibre for reinforcing plaster board. He took the opportunity to study some of the problems associated with the utilization of local products for pulp and board making.

Dr. R. H. Kirby, Assistant Director in charge of the Economics Division, took part in field trials of fibre extraction machinery in Kenya and Tanganyika in May and June. He later discussed fibre and economic problems with the authorities in Zanzibar, Northern and Southern Rhodesia, the Union of South Africa and Mauritius.

During November and December Miss E. Orr, in charge of the Market Surveys Section, visited the Stanford Research Institute, California, to study their small scale industry programme for underdeveloped areas. She also discussed economic problems and explained the work of the Economics Division to the authorities in Jamaica, Antigua, Barbados, Grenada, Trinidad and British Guiana.

INTERNATIONAL MEETINGS

Dr. R. A. E. Galley, Director, attended meetings of the Crops Protection Division (as Secretary) and the Applied Chemistry Section of the International Union of Pure and Applied Chemistry held in Munich in August.

Dr. W. D. Raymond, O.B.E., attended the meeting of the Oils and Fats Division of the International Union of Pure and Applied Chemistry held in Munich in August. He also attended the meeting of the International Society for Fat Research at Graz in early September, where he read a paper on the "Effects of Tropical Storage on the

Value of Groundnuts as an Oilseed". In October he attended the symposium on "Enzymes in the Manufacture, Storage and Distribution of Food" at the Society of Chemical Industry, where he opened the discussion on "Enzymic Deterioration in Vegetable Oils and Oilseeds".

Dr. G. B. Pickering attended the 2nd International Congress on Essential Oils in Grasse, in July.

Mr. A. E. Chittenden attended the combined Fifth European T.A.P.P.I. Study Group and European Committee for Paper (EUCEPA) Conferences, at Noordwijk-on-Sea, Holland, in June.

Mr. E. H. G. Smith and Mr. D. E. Kay presented a paper entitled "The Utilization of Citrus Fruits" to a meeting on the Utilization of Apples and Citrus Fruits, held in London in June. The meeting was arranged jointly by the Commonwealth Fruits Council, the Food Group of the Society of Chemical Industry and the National Farmers' Union.

DIRECTOR'S ADVISORY COMMITTEE

A meeting of the Oil Palm Sub-Committee of the Consultative Committee on Oils and Oilseeds was held in August under the Chairmanship of Professor T. P. Hilditch, C.B.E., F.R.S. The meeting was held in order to discuss the Institute's work on the causes of difficulty in bleaching Nigerian palm oil. The possibility of initiating a study of the role that moulds and bacteria play in the lipolysis of palm oil was also considered.

APPENDIX II

COUNTRIES FROM WHICH ENQUIRIES HAVE BEEN RECEIVED APRIL—DECEMBER, 1959

Country		*Country*	
Aden	4	Malaya	13
Angola	2	Maldive Is.	2
Australia	10	Malta	14
Azores	1	Mauritius	9
Bahama Is.	2	Mexico	1
Barbados	2	Mozambique	1
Bechuanaland	1	New Zealand	5
Belgian Congo	1	Nigeria	48
Bermuda	1	Northern Rhodesia	5
Borneo, N.	4	Norway	2
Brazil	5	Nyasaland	8
British Guiana	7	Pakistan	8
British Honduras	14	Paraguay	1
British Solomon Is.	1	Peru	1
Burma	2	Portugal	3
Cambodia	1	St. Helena	3
Canada	2	St. Vincent	1
Ceylon	5	Sarawak	6
Colombia	1	Seychelles Is.	12
Cuba	1	Sierra Leone	5
Cyprus	15	Singapore	3
Ecuador	1	Somaliland	3
Falkland Is.	1	South Africa	19
Fiji	10	Southern Cameroons	3
Finland	1	Southern Rhodesia	5
Gambia	2	Spain	1
Germany	1	Sudan	7
Ghana	12	Swaziland	8
Holland	1	Sweden	2
India	6	Tanganyika	23
Indonesia	1	Thailand	2
International	20	Tobago	1
Iran	2	Tonga	2
Iraq	2	Trinidad	1
Italy	1	Uganda	7
Jamaica	19	United Kingdom	211
Japan	1	U.S.A.	5
Kenya	66	Venezuela	2
Leeward Is.		Vietnam	1
Antigua	8	Windward Is.	
Montserrat	2	Dominica	5
St. Kitts	1	Grenada	4
Libya	4	Zanzibar	5
Madagascar	1	Total No. of counries 81	
		Total enquiries 713	

APPENDIX III

STAFF OF THE TROPICAL PRODUCTS INSTITUTE
31st DECEMBER, 1959

Director: R. A. E. Galley, Ph.D., A.R.C.S., D.I.C., F.R.I.C.
Personal Assistant: Mrs. F. E. Warren.

ADVISORY DIVISION

Assistant Director: T. A. Oxley, B.Sc., A.R.C.S., M.Inst.Biol.
Personal Assistant: Mrs. J. K. James.
Typist: Miss K. Gahan.

Section I, Essential Oils

Principal Scientific Officer: G. B. Pickering, M.A. B.Sc., D.Phil., A.R.I.C.
Senior Scientific Officer: G. E. Howard, B.Sc., Ph.D., A.R.I.C.
Senior Experimental Officers: E. G. Brown, B.Sc., W. S. A. Matthews, A.R.I.C.
Assistants (Scientific): Miss E. E. Edwards, M. I. Kaits.

Section II, Oils, Fats, Waxes

Principal Scientific Officer: W. D. Raymond, O.B.E., B.Sc., Ph.D., F.R.I.C.
Senior Scientific Officer: J. A. Cornelius, B.Sc., Ph.D., A.R.I.C.
Assistant Experimental Officers: J. H. Broadbent, A. T. Umoh.
Assistant (Scientific): P. S. Beevor.

Microbiology Section

Experimental Officer: Miss A. J. Sheridan, B.Sc.
Assistant (Scientific): Miss V. Cole.

Section III, Foods, Feeding stuffs

Principal Scientific Officer: L. H. Greenwood-Barton, B.Sc., F.R.I.C., F.R.S.H.
Scientific Officer: D. Halliday, B.Sc.
Experimental Officer: Mrs. P. L. K. Coveney, B.Sc.
Assistant Experimental Officers: B. H. Barnes, A. Hoffman.
Assistant (Scientific): T. P. A. Mellon.

Section IV, Drugs, Insecticides

Principal Scientific Officer: A. J. Feuell, B.Sc., Ph.D., A.R.I.C.
Senior Scientific Officer: J. A. Dawson, B.Sc., A.R.I.C.
Experimental Officer: L. Donegan.
Assistant Experimental Officer: T. W. Hammonds.
Assistant (Scientific): Miss I. Goodman.

Section V, Fruit, Vegetables

Chief Experimental Officer: E. H. G. Smith, M.A.
Experimental Officers: P. C. Crowther, Miss J. H. Gawler, B.Sc., Mrs. D. E. Kay.

Section VI, Animal products

Experimental Officer: R. D. Coveney, B.Sc.

Section VII, Fibres

Senior Scientific Officer: Miss V. Laws, M.Sc.
Experimental Officers: Miss J. S. Ingram, C. G. Jarman, B.Sc., M.Inst.Biol.

Section VIII, Pulp and paper-making

Senior Experimental Officer: A. E. Chittenden.
Experimental Officer: E. R. Palmer.
Assistants (Scientific): Miss H. J. Cosburn, W. G. Sparksman.

RESEARCH DIVISION

Assistant Director: L. Horton, B.Sc., Ph.D., A.R.C.S., D.I.C., A.R.I.C.
Personal Assistant: Miss T. M. Bertram.

Section A, Organic Chemistry

Experimental Officer: G. G. Shone, B.Sc.
Assistant (Scientific): Miss P. J. Rose.

Section B, Sugar Esters

Scientific Officer: G. R. Ames, B.Sc., Ph.D.
Assistant Experimental Officer: Mrs. M. M. Blackmore.
Assistant (Scientific): T. A. King.

Section C, Pyrethrum

Principal Scientific Officer: E. M. Thain, B.Sc., Ph.D., A.R.I.C.
Assistants (Scientific): Miss H. Inglis, M. Snarey.

Section D, Plant Chemistry

Senior Scientific Officer: K. Sargeant, B.Sc., Ph.D.
Assistant Experimental Officer: J. C. O'Kelly.
Assistant (Scientific) : Miss D. P. Dore.

Section E, Physical Chemistry

Principal Scientific Officer: H. J. Dothie, B.Sc., F.R.I.C.
Senior Scientific Officer: T. J. Coomes, B.Sc.
Assistant Experimental Officers: D. J. Crook, A. B. Wood, B.Sc.

ECONOMICS DIVISION

Assistant Director: R. H. Kirby, B.Com., Ph.D.
Personal Assistant: Miss E. M. Farrier.
Shorthand Typist: Miss V. E. Dennis.

Market Surveys Section

Principal Scientific Officer: Miss E. Orr, B.Sc.(Econ.)
Scientific Officer: M. G. A. Chadwick.
Assistant Experimental Officer: P. J. R. Breslin.

Statistics Section

Higher Executive Officer: Mrs. J. E. Balding.
Clerical Officers: Miss A. Devine, R. Pope.

Bulletin Section

Experimental Officer: Miss M. Kershaw, B.Com.

ADMINISTRATION AND DEVELOPMENT DIVISION

Assistant Director: P. C. Spensley, M.A., B.Sc., D.Phil., F.R.I.C.
Personal Assistant: Miss D. Huddlestone.
Typist: Miss D. Lester.

Development Section

Principal Scientific Officer: L. R. B. Shackleton, B.Sc., Ph.D., F.R.I.C.
Senior Experimental Officer: C. C. Noaks, B.Sc., A.R.I.C.
Assistant (Scientific): A. R. Sims.

Workshop

Experimental Officer: L. J. Beer.
W.T.O. IV: A. L. Brooks.
Laboratory Mechanics: R. A. Evans, A. E. Head, M. Swan.

Scientific Liaison Section

Senior Scientific Officer: S. S. Bampton, B.Sc., Ph.D.
Scientific Officer: Miss A. Male, B.Sc.
Assistant Experimental Officer: Miss M. S. Orr, B.Sc.
Clerical Officer: A. G. Kenyon, M.B.E.

Library

Librarian Grade II: H. E. Thrupp, A.L.A.
Librarian Grade IV: N. J. Day, A.L.A.
Clerical Officers: Mrs. B. Bird, Miss B. Chuter, Mrs. M. J. Knights.
Typist: Miss E. N. O'Flanagan.
Paper Keepers: H. F. Newman, B. J. Stone.

Technical Index

Experimental Officers: Miss V. Clarke, B.Sc., Mrs. U. Johnson, B.Sc., Miss S. M. G. McDonald.

Bookbinding

Bookbinder: H. Brown.
Hand Sewer: Miss E. Glover.

Administration Section

Higher Executive Officer: L. F. West.
Executive Officer: R. W. Jenner.

Finance and Personnel

Clerical Officers: D. C. J. Hazell, Miss M. F. M. Norman, W. G. Whiting.
Typist: Miss M. E. Collingwood.

Registry

Executive Officer: D. J. Church.
Clerical Officers: Mrs. W. E. Devine, Mrs. A. R. Griffiths, B. R. Hale.
Paper Keeper: F. J. Davies.

Typing

Shorthand Typists Grade I: Mrs. M. H. L. McAlden, Miss C. A. Hall, Miss E. E. Jacobs, Miss J. A. Sims.
Typist Grade II: Miss J. I. DaCosta.

Telephones

Telephonists: Mrs. E. M. Smith, Mrs. Y. M. Woods.

Laboratory Management Section

Senior Assistant (*Scientific*)*:* F. A. Lee.

Laboratory Services

Laboratory Attendants: S. G. Blumer, Mrs. M. Brooks, Miss A. L. Clark, H. E. Gant, Miss H. Griffith, Mrs. M. Metcalf, Mrs. F. E. White.

Stores

Clerical Officer: D. S. Taylor.
Clerical Assistant: Miss G. M. Smith.
Laboratory Attendants: St. B. Doyle, A. Warner.
Shorthand Typist Grade I: Miss M. Selby.

Office Services

Office Keeper: H. Hawkes.
Senior Messenger: E. Goode.
Messengers: A. E. Cassola, J. Delahunty, A. C. Lloyd, F. G. Tanner, T. Trundle.

APPENDIX IV

PAPERS PUBLISHED IN 1959

1. The Tropical Products Institute. *Chemistry & Industry*, 1959, 1570-1573.
2. Bennett, Miss H., and Coveney, R. D., Mangrove bark from Sarawak, *Tropical Science*, 1959 **1** (2), 116-130.
3. Cornelius, J. A., Raymond, W. D., and Ward, J. B., Wild sesame seed from Kenya. *Tropical Science*, 1959, **1** (3), 212-214.
4. Galley, R. A. E., Colonial research: Natural products and pesticides. *Chemistry & Industry*, 1959, 1326-1332.
5. Neish, Mrs. S. G., Orr, Miss M. S., and Spenseley, P. C. Methods for the reduction of evaporation from water surfaces. *Tropical Science*, 1959, **1** (2), 107-111.
6. Raymond, W. D., and Squires, Miss J., Sources of starch in Colonial territories, II: Arrowroot (Maranta *arundinacea* Linn). *Tropical Science*, 1959, **1** (3), 182-192.
7. Raymond, W. D., Whiston, A., and Hay, R. J., The effect of storage for different periods on the quality of groundnuts, with special reference to their value for the manufacture of protein fibres. *Tropical Science*, 1959, **1** (3), 149-181.
8. Thrupp, H. E., Libraries in the area: Tropical Products Institute Library. *The London Librarian*, 1959, **5** (4), 3.

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